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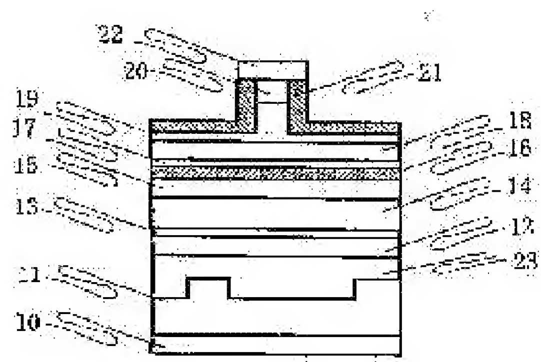
(54) SEMICONDUCTOR LIGHT-EMITTING DEVICE AND ITS MANUFACTURING METHOD, AND OPTICAL INFORMATION RECORDER /REPRODUCER

(57)Abstract:
PROBLEM TO BE SOLVED: To shorten a carrier lifetime of an active layer, except in a current injected region.
SOLUTION: A method for manufacturing a semiconductor light-emitting device comprises steps of laminating a plurality of nitride semiconductor layers on an n-type GaN substrate 11, and forming a stripe-like waveguide. The method further comprises a step of forming a groove of a recess region, on a region opposed to the stripe-like waveguide. The central part of the groove of the recess region becomes a high part of a defect density, excepting the central part. The method also comprises a step of forming a pair of protruding regions of lands, in the groove of the recess region. Thus, the groove of the recess region is disposed between the lands of the pair of the protruding regions. One protruding region of the land is formed near the groove of the recess region.



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CLAIMS

[Claim(s)]

[Claim 1]Are the semiconductor emission device with which two or more nitride semiconductor layers were laminated, and a stripe shape waveguide was formed on a substrate, and in this substrate face. A semiconductor emission device, wherein a convex domain of a couple is formed and one convex domain is formed near [concave region] this so that a concave region may be formed in a field which counters this stripe shape waveguide.

[Claim 2]The semiconductor emission device according to claim 1 which said concave region is formed between convex domains of said couple, and said stripe shape waveguide counters between this one convex domain and a center section of this concave region, and is arranged.

[Claim 3]Are the semiconductor emission device with which two or more nitride semiconductor layers were laminated, and a stripe shape waveguide was formed on a substrate, and in this substrate face. A semiconductor emission device characterized by forming a high field of defect density near the field of the low defect density so that a field which counters this stripe shape waveguide may turn into a low field of defect density.

[Claim 4]Ten or more times [of defect density of a field where said defect density counters said stripe shape waveguide] the semiconductor emission device according to claim 3.

[Claim 5]The semiconductor emission device according to claim 3 in which said defect density is 10^8 / more than cm^2.

[Claim 6]The semiconductor emission device according to claim 3 with which an interval of a high field of said defect density and said stripe shape waveguide is 0.5 micrometer - 4 micrometers.

[Claim 7]The semiconductor emission device according to claim 3 which has the saturable absorption field where a high field of said defect density is provided with the characteristic that the amount of absorption of light is saturated.

[Claim 8]The semiconductor emission device according to claim 1 or 3 whose stripe width of said stripe shape waveguide is 0.5 micrometer - 8 micrometers.

[Claim 9]The semiconductor emission device according to claim 1 to 8 which has a self-oscillation feature by said stripe shape waveguide and said saturable absorption field.

[Claim 10]A process of forming a convex domain and a concave region which adjoin mutually on a nitride semiconductor substrate of the 1st conductivity type, A process of forming a nitride semiconductor layer of the 1st conductivity type with the 1st growing temperature on a nitride semiconductor substrate of this 1st conductivity type, On a nitride semiconductor layer of this 1st conductivity type, with this 1st growing temperature and the 2nd different growing temperature, a nitride semiconductor crack prevention layer of the 1st conductivity type, A process of forming a nitride semiconductor cladding layer of the 1st conductivity type, and a nitride semiconductor guide layer of the 1st conductivity type in order with this 1st growing temperature, A process of forming a nitride semiconductor active layer of the 1st conductivity type with this 2nd growing temperature and the 3rd different growing temperature on a nitride semiconductor guide layer of this 1st conductivity type, On a nitride semiconductor active layer of this 1st conductivity type, with this 1st growing temperature, a nitride semiconductor barrier layer of the 2nd conductivity type, A manufacturing method of a semiconductor emission device including a process of forming a nitride semiconductor guide layer of the 2nd conductivity type, a nitride semiconductor cladding layer of the 2nd conductivity type, and a nitride semiconductor contact layer of the 2nd conductivity type in order, and a process of forming ridge structure by dry etching processing.

[Claim 11]Optical information storage playback equipment, wherein the semiconductor emission device according to any one of claims 1 to 9 is used as a light source.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention is used for the information storage of an optical disc, playback, etc., and it relates to a semiconductor emission device which has a self-oscillation feature for low-noise-izing, a manufacturing method for the same, and optical information storage playback equipment while horizontal transverse mode is stable.
[0002]
[Description of the Prior Art]With the increase in the storage capacity in an optical disc, as a light source for optical discs, the diameter of condensing is made small and the light source with a wavelength of around 400 nm which can record information in high density further is needed. Use of the material of a cheap plastic system is considered by the optical disk system to a lens, a disk, etc. for cost reduction. However, since an absorption-of-light end is the wavelength of about 390 nm at the maximum, the material of such a plastic system needs to perform further short wavelength formation as a light source for optical discs. For this reason, it is not easy for it to be necessary to examine the material as a light source, and to deal with fertilization. The semiconductor laser is conventionally used for the light source of such an optical disk system.
There is a gallium nitride compound semiconductor as a typical material of the semiconductor laser which has the wavelength of around 400 nm.

[0003]When nitrides semiconductor laser is used for an optical disk system etc., in order that the returned light noise from reflective spots, such as an optical disc, may be decreased, a structure provided with the self-oscillation feature is used.
[0004]Such nitrides semiconductor laser is indicated by JP,10-294532,A.
Drawing 4 is a sectional view showing a typical structure of the nitrides semiconductor laser.
By using for this gazette as a field (it is hereafter considered as a saturable absorption field) which has the saturable absorption characteristic that the amount of absorption of light is saturated in the island like areas of In which is a nonluminescent field, in the adjoining field of the active layer containing InGaN, A self-oscillation function is obtained and the semiconductor laser which returned light noise reduced is indicated.
[0005]As shown in drawing 4, as for this semiconductor laser, n type GaN buffer layer 71 and the n type GaN contact layer 72 are formed on the sapphire substrate 70.
On the predetermined field of the n type GaN contact layer 72, The n type AlGaN clad layer 73, the n type InGaN/GaN multiplex quantum well adjacent layer 74 which has island like areas of In, the InGaN/GaN multiplex quantum well active layer 75, the p type GaN adjacent layer 76, and the p type AlGaN clad layer 77 are laminated in order.
The stripe shape waveguide area 78a which constitutes a laser cavity is established in the center section on the p type AlGaN clad layer 77.
The n type GaN energization barrier layer 79 into which current is not made to pour in addition to a waveguide is formed in the outside of the stripe shape waveguide area 78a.
On the portion of the stripe shape waveguide area 78a, and the n type GaN energization barrier layer 79, the p type GaN contact layer 78 is formed. And the p lateral electrode 80 is formed on the p type GaN contact layer 78.
The n lateral electrode 81 is formed in portions other than the predetermined field of the above-mentioned on the n type GaN contact layer 72.

[0006]
[Problem(s) to be Solved by the Invention]The nitrides semiconductor laser indicated by JP,10-294532,A, In the

adjoining field of an active layer, since the island like areas 82 of In which is a nonluminescent field are used as a saturable absorption field, There is a possibility that a process control for forming an element to obtain a good self-oscillation feature easily as a result may become difficult carrying out a process control so that the island like areas 82 of In which produces optical absorption may hold a good absorption feature.
[0007]Without forming such island like areas 82 of In so that the saturable absorption characteristic may be given positively, By using the field of the active layer currently formed in the lower part of the field (energization barrier layer) where the current of the outside of a stripe shape waveguide is not poured in as a saturable absorption field, the art of the low noise semiconductor laser whose self-oscillating motion becomes possible is known. In this case, in order to make the self-oscillation of a low noise semiconductor laser maintain effectively, it is necessary to the carrier life of the active layer of a current injection region to shorten the carrier life of active layers other than a current injection region. However, it is not easy to be hard to diffuse the career generated by optical absorption in the saturable absorption field, and to shorten the life of the career on appearance in a nitride semiconductor, since the diffusion coefficient of a career is small, either.
[0008]In the conventional semiconductor laser, it is difficult to fully stabilize horizontal transverse mode at the time of high output operation, and there is a possibility that the noise which is change of optical power may be made.
[0009]This invention solves such a technical problem. The purpose shortens the carrier life of active layers other than a current injection region, and there is in providing a semiconductor emission device with which the self-oscillation feature where horizontal transverse mode was stabilized also in the time of high output operation is obtained, a manufacturing method for the same, and optical information storage playback equipment.

[0010]
[Means for Solving the Problem]A semiconductor emission device of this invention is a semiconductor emission device with which two or more nitride semiconductor layers were laminated, and a stripe shape waveguide was formed on a substrate, and in this substrate face. A convex domain of a couple is formed and one convex domain is formed near [concave region] this so that a concave region may be formed in a field which counters this stripe shape waveguide.
[0011]Said concave region is formed between convex domains of said couple, and said stripe shape waveguide counters between this one convex domain and a center section of this concave region, and is arranged.
[0012]A semiconductor emission device of this invention is a semiconductor emission device with which two or more nitride semiconductor layers were laminated, and a stripe shape waveguide was formed on a substrate, and in this substrate face. A high field of defect density is formed near the field of the low defect density so that a field which counters this stripe shape waveguide may turn into a low field of defect density.
[0013]Said defect density is 10 or more times of defect density of a field which counters said stripe shape waveguide.
[0014]Said defect density is 10^8 / more than cm^2.
[0015]An interval of a high field of said defect density and said stripe shape waveguide is 0.5 micrometer - 4 micrometers.
[0016]A high field of said defect density has a saturable absorption field provided with the characteristic that the amount of absorption of light is saturated.
[0017]Stripe width of said stripe shape waveguide is 0.5 micrometer - 8 micrometers.
[0018]It has a self-oscillation feature by said stripe shape waveguide and said saturable absorption field.
[0019]A process at which a manufacturing method of a semiconductor emission device of this invention forms a convex domain and a concave region which adjoin mutually on a nitride semiconductor substrate of the 1st conductivity type, A process of forming a nitride semiconductor layer of the 1st conductivity type with the 1st growing temperature on a nitride semiconductor substrate of this 1st conductivity type, On a nitride semiconductor layer of this 1st conductivity type, with this 1st growing temperature and the 2nd different growing temperature, a nitride semiconductor crack prevention layer of the 1st conductivity type, A process of forming a nitride semiconductor cladding layer of the 1st conductivity type, and a nitride semiconductor guide layer of the 1st conductivity type in order with this 1st growing temperature, A process of forming a nitride semiconductor active layer of the 1st conductivity type with this 2nd growing temperature and the 3rd different growing temperature on a nitride semiconductor guide layer of this 1st conductivity type, On a nitride semiconductor active layer of this 1st conductivity type, with this 1st growing temperature, a nitride semiconductor barrier layer of the 2nd conductivity type, A process of forming a nitride semiconductor guide layer of the 2nd conductivity type, a nitride semiconductor cladding layer of the 2nd conductivity type, and a nitride semiconductor contact layer of the 2nd conductivity type in order, and a process of forming ridge

structure by dry etching processing are included.
[0020]As for optical information storage playback equipment of this invention, the semiconductor emission device according to any one of claims 1 to 9 is used as a light source.
[0021]
[Embodiment of the Invention]The self-oscillation of a semiconductor laser is produced by the interaction of the career in the active layer (gain region) which the population inversion has produced with the career poured into the semiconductor laser, and the saturable absorption field which is fields provided with the saturable absorption characteristic, and a photon. . [whether the band gap substantial to the 1st of the characteristic required of a saturable absorption field is the same as that of the band gap of an active layer (gain region), and] Or it is slightly narrow, and the 2nd characteristic required of a saturable absorption field is that the life of the career of a saturable absorption field is shorter than the life of the career of an active layer, that the absorption of light is saturated easily, etc. in order to make self-oscillation cause effectively.
[0022]In nitrides semiconductor laser, especially the life characteristic of the career in the saturable absorption field which is the 2nd characteristic required of a saturable absorption field is important. In order to know several ns and a short thing at the minimum and for the life of the career of a nitride system semiconductor to distinguish [clear] between the life of the career of an active layer and a saturable absorption field, It is possible to add impurity elements (for example, Mg etc.) at high concentration to a saturable absorption layer (doping), to promote diffusion of the career from the optical absorption field in a saturable absorption field to the outside of an optical absorption field, to make a career recombine efficiently, and to shorten the carrier life on appearance, etc.
[0023]In the conventional nitrides semiconductor laser, the current injection region (oscillation region corresponding to a stripe shape waveguide) of an active layer However, a gain region, When making it into the saturable absorption field which has the saturable absorption characteristic except the current injection region of an active layer, it is not easy clear to distinguish between the amount of addition (dope) of an impurity element in the field of both a gain region and a saturable absorption field. In order to shorten seemingly the life of the career generated by the saturable absorption field by optical absorption, the material property of the saturable absorption field which has a big diffusion coefficient which the generated career diffuses outside an optical absorption field to the order for several ns is required, but. In the saturable absorption field formed of InGaN etc., generally, since the diffusion coefficient is small, a career is made to recombine and the effect which shortens the life of a career is hard to be acquired by fully diffusing the career generated by the saturable absorption field.
[0024]By using for a GaN board the process of forming a level difference, about this point, in this invention, as a result of repeating examination, To the field in which the gain region and saturable absorption field of a semiconductor laser are formed. So that the high field of defect density and the low field of defect density may be formed, the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a gain region may be periodically arranged to the low field of defect density and the current injection region which is a gain region may be approached, By arranging the saturable absorption field which has the saturable absorption characteristic to the high field of defect density, the recombination of the prompt career by unradiated transition becomes possible. As a result, while the life of the effectual career in the saturable absorption field which is a high field of the defect density of the outside of the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a gain region in the formation area of a semiconductor laser becomes short, Self-oscillation becomes is easy to maintain in a gain region, and the nitrides semiconductor laser in which self-oscillation is possible to high power is obtained.
[0025]Near the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a low gain region of defect density, in this way, The absorption of light in the high saturable absorption field of this defect density can fully be maintained at the time of operation of a semiconductor laser by arranging the field which has the saturable absorption characteristic that defect density is high and the life of a career is short compared with a current injection region (oscillation region corresponding to a stripe shape waveguide). As a result, in nitride system semiconductor laser, By making into a predetermined value the difference of the defect density of the current injection region (oscillation region corresponding to a stripe shape waveguide) and the high saturable absorption field of defect density which are low gain regions of defect density, At the time of operation of nitride system semiconductor laser, the difference of the profit in the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a low gain region of defect density, and the absorption in the high saturable absorption field of defect density can be clearly attached now, Horizontal transverse mode comes to be stabilized to high power.
[0026]This invention is based on such knowledge.

[0027]In the nitrides semiconductor laser which attached the slot which forms a level difference in the surface of a GaN board, the land which is a convex domain of a level difference, and the groove which is the concave regions of a level difference are periodically formed by turns on the surface of a GaN board. When predetermined conditions prescribed these widths of land, the width of a groove, the depth of a groove, and the thickness of the re-growth phase formed on the GaN board which has stepping structure, according to the stepping structure, it has checked that the high field of defect density and the low field of defect density existed in a re-growth phase. By etch pit observation and TEM (transmission electron microscope) observation of this re-growth phase, it has also checked that the high field of defect density was formed in the center portion on the upper surface of a groove, and the land upper surface. In [as for this, the growth from the side of a land is chosen from the growth from the upper surface of a groove as dominance at the time of the re-growth from the GaN board for which the level difference was formed as for the re-growth phase, and] a groove top as a result, Defects, such as penetration dislocation, converge on the center portion on a groove, and are considered that defects, such as penetration dislocation, decrease in fields other than the center portion on a groove.
[0028]That the upper surface of a land or the center portion of a groove has not been thoroughly buried with a re-growth phase, and the slot on the level difference remains when the thickness of a re-growth phase is thin for a certain reason. The conditions in which a level difference is formed were changed, the field with various defect density was formed, and the stability of change of the self-oscillation feature of nitrides semiconductor laser and the horizontal transverse mode at the time of high output operation was investigated.
[0029]If the low field of defect density has good crystallinity and the stripe shape waveguide (current injection region which is a gain region) of ridge structure is formed in this field, the poured-in career, Radiation recombination was carried out effectively and nitrides semiconductor laser with high slope efficiency which is a rate of the increase in light intensity over the rate of the increase in an inrush current was obtained. In the high field of defect density, the rate of the relaxation to the low energy level resulting from the rate and defect of unradiated recombination increases, and the recombination of the career generated by the optical absorption in active layers other than the current injection region which is a gain region is promoted. As a result, the life of the career of the saturable absorption field which is a high field of defect density becomes short, and is effective for stabilization of horizontal transverse mode continuation of the self-oscillation in nitrides semiconductor laser, and high-output.
[0030]As mentioned above, it is better for the one where the difference of the defect density of the high portion of defect density and the low portion of defect density is larger to change steeply [the difference of defect density] well the optimal on the boundary as a substrate required of the nitrides semiconductor laser which has a self-oscillation feature.
[0031]When this invention examines the conditions for which a level difference is formed in a GaN board about such a point, if the depth of 4 micrometers - 30 micrometers, and a groove is 1 micrometer - 10 micrometers, groove width 0.1 micrometer - 5 micrometers, and a re-growth phase, The check of being effective in the nitrides semiconductor laser which has a self-oscillation feature was obtained. Here, in the depth of a groove, if thickness of the re-growth phase on A and a groove is set to B, and it is 20A>=B>=2A, the above-mentioned effect will be acquired. As a result of observing the surface of the GaN board which has such stepping structure, the high field of defect density and the low field of defect density had produced on the center section of the upper surface of the groove on a GaN board, and the upper surface of the land, respectively. What is necessary is just to set a land width as 3 micrometers - about 20 micrometers, in arranging a land and a groove periodically on a GaN board. What is necessary is just to form a groove on a GaN substrate face at this time, so that a stripe shape waveguide may be countered. By being symmetrically arranged to the stripe shape waveguide (current injection region which is a gain region) of ridge structure, the light distribution in horizontal transverse mode is applicable, and the high field of defect density has it. [preferred] As a result, groove width should just be 10 micrometers - 20 micrometers. The defect density of the high field of defect density is 10 or more times of the defect density of the low field of defect density, and the defect density of the high field of defect density should just be more than 10^8cm^{-2}.
[0032]Next, arrangement of the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a gain region, Since the amount of absorption of light in the saturable absorption field for control of a self-oscillation feature and stabilization of horizontal transverse mode needs to be controlled, The design of the thickness of an active layer, the distance from a saturable absorption field to the end of the stripe shape waveguide of ridge structure, stripe width (width of an average of the upper part of ridge structure and the lower part), etc. is needed. As for stripe width, the good result was obtained in 0.5 micrometer - 8 micrometers, and, as for the distance to the end of the stripe shape waveguide of ridge structure, the good result was obtained from the high saturable absorption field of defect density in 0.5 micrometer - 4 micrometers. If stripe

width is set to less than 0.5 micrometer, the light distribution of the horizontal transverse mode in a gain region will become small, and profit sufficient as a semiconductor laser will not be acquired. If stripe width is expanded, can set the light distribution in active layers other than the gain region equivalent to a saturable absorption field as the suitable range, and the effect which shortens the life of a career will be easy to be acquired, but if stripe width exceeds 8 micrometers, The threshold current used as the laser oscillation starting point becomes high, and a long life is not acquired as a semiconductor laser.
[0033]In order that the high field of defect density may shorten the life of the career generated in active layers other than the current injection region which is a gain region by relaxation to the low energy level resulting from unradiated recombination and a defect, It is necessary to arrange in the distance which can diffuse the career which has been arranged at the skirt of the light distribution of the horizontal transverse mode in a laser oscillation state, or was generated in time shorter than the life (severalns-) of the career of the active layer of the current injection region which is a gain region. When the distance from the high saturable absorption field of defect density to the end of the stripe shape waveguide of ridge structure is less than 0.5 micrometer, The inside of the current injection region (oscillation region) of a stripe shape-like waveguide is covered with the high field of defect density, the threshold current used as the laser oscillation starting point goes up remarkably, and there is a possibility that continuous oscillation may not be carried out in a room temperature.
[0034]If the distance from the high saturable absorption field of defect density to the end of the stripe shape waveguide of ridge structure exceeds 4 micrometers, the self-oscillation feature as a semiconductor laser will not be obtained, and, similarly the stability of the light distribution of the horizontal transverse mode at the time of high power will not be obtained. In order that from the skirt of the light distribution of the horizontal transverse mode in a laser oscillation state to the saturable absorption field which is a high field of defect density may leave this too much, It is because the career generated by optical absorption cannot be spread to the high saturable absorption field of defect density in a short time and effects, such as unradiated recombination, are not acquired.
[0035]As for an active layer, it is preferred to have multiple quantum well structure, and if the thickness of an active layer is 5 nm - 200 nm as the sum of a quantum well layer and a barrier layer, a self-oscillation feature will be obtained in nitrides semiconductor laser. case the thickness of an active layer is thick -- the ratio of vertical optical confinement factor gamma and thickness d of an active layer -- if gamma/d is fixed, in fixed optical power, a light absorption amount will become large rather than the case where the thickness of an active layer is thin. Since the carrier density in the active layer of the current injection region which is a gain region also decreases in this case, the life of a career also becomes long and self-oscillation happens easily in nitrides semiconductor laser. However, if the thickness of an active layer exceeds 200 nm as a result of the threshold current used as the laser oscillation starting point becoming high and pouring electric power's becoming large since a profit is hard to be acquired in the current injection region which is a gain region when the thickness of the active layer became thick too much, even if it carries out continuous oscillation, it will quench for a short time.
[0036]Thus, in this invention, the nitrides semiconductor laser which has the structure of reducing the noise induced by returned light was obtained by attaching the slot which forms a level difference in the surface of a GaN board with the self-oscillation where horizontal transverse mode was stabilized in broad optical power.
[0037]Drawing 1 is a cross-sectional view of the nitrides semiconductor laser which is a semiconductor emission device of a 1st embodiment of this invention.
[0038]On the n type GaN board 11 with which the slot which forms a level difference in the surface is attached, The n type GaN re-growth phase 23, the n type GaN layer 12, the n type InGaN crack prevention layer 13, the n type AlGaN clad layer 14, the n type GaN guide layer 15, the n type InGaN active layer 16, the p type AlGaN barrier layer 17, and the p type GaN guide layer 18 are laminated in order. The p type AlGaN clad layer 19 is laminated by the p type GaN guide layer 18, the p type AlGaN clad layer 19 has ridge structure which the center section of the cross direction which intersects perpendicularly with a stripe direction projected, and the p type GaN contact layer 20 is laminated on the lobe. In the side of the p type AlGaN clad layer 19 and the p type GaN contact layer 20, on the p type AlGaN clad layer 19. Except for the upper surface of the p type GaN contact layer 20, the insulator layer 21 is formed and the p type electrode 22 is formed in the upper surface of the insulator layer 21 and the p type GaN contact layer 20. The n type electrode 10 is formed in the n type GaN board 11 side.
[0039]Thus, the nitrides semiconductor laser which is a 1st embodiment of this invention shown in drawing 1 has the stripe shape refractive-index waveguide which used ridge structure.
[0040]Drawing 2 is a mimetic diagram showing the physical relationship of the stripe shape waveguide which is a current injection region of the nitrides semiconductor laser shown in drawing 1, and the high defect density field

which is saturable absorption fields. In drawing 2, the field A shows the low defect density field which has a stripe shape waveguide which is a current injection region where defect density is low, and the high defect density field whose field B is a saturable absorption field where defect density is high, and L shows the distance from the end of a stripe shape waveguide to the center of a high defect density field. In drawing 2, stripe width is 2 micrometers and L is 1 micrometer. As for the cavity length of nitrides semiconductor laser, the rear-face reflectance of a resonator of 450 micrometers and the front reflectance of a resonator is 85% 20%. The depth of a ridge is adjusted so that a horizontal optical confinement factor may be set to 0.88-0.97.

[0041]The manufacturing method of the nitrides semiconductor laser which is a 1st embodiment of this invention is explained below, referring to drawing 1. The epitaxial grown method shown below is a method of growing up a crystal film on a substrate, VPE (the gaseous phase -- epitaxial) -- law and CVD (chemicals gaseous phase deposition) -- law. MOVPE (the organic metal gaseous phase -- epitaxial) -- law and MOCVD (organometal chemistry gaseous phase deposition) -- law. Halide-VPE (the halogenation study gaseous phase -- epitaxial) -- law, the MBE (molecular beam epitaxial) method, and MOMBE (an organometallic molecule line -- epitaxial) -- law and GSMBE (gaseous raw material molecular beam epitaxial) -- law and CBE (a chemicals beam -- epitaxial) -- law etc. are included.

[0042]First, the n type GaN board 11 is formed. On the GaN single crystal membrane of about 500-micrometer thickness, a pitch interval is 20 micrometers and the n type GaN board 11 provides a depth of 2.5 micrometers, and an about [width 15micrometer] slot (groove) in a pitch interval.

[0043]Next, each gallium nitride semiconductor layer which nitrides semiconductor laser constitutes is laminated with an epitaxial grown method on the n type GaN board 11. In this case, the n type GaN board 11 is first set in the furnace of a MOCVD (organometal chemistry gaseous phase deposition) device, Using NH_3 of V group material, and TMGa (trimethylgallium) of a group III material, a low-temperature GaN buffer layer is grown up with the growing temperature of 550 **, and a 25-nm-thick low-temperature GaN buffer layer is formed on the n type GaN board 11. On this low-temperature GaN buffer layer, temperature up is carried out to the growing temperature of 1075 **, SiH_4 is added to two kinds of above-mentioned raw materials, and the n type GaN re-growth phase 23 about 3.5 micrometers thick is newly laminated with an epitaxial grown method. The 0.5-micrometer-thick n type GaN layer 12 (Si-impurity concentration $1x10^{18}/cm^3$) is formed on the n type GaN re-growth phase 23.

[0044]Then, lowering growing temperature at 700 ** - about 800 **, and supplying TMIn (trimethylindium) which is a group III material. On the n type GaN layer 12, a n type $In_{0.07}Ga_{0.93}N$ layer is grown up, and the 50-nm-thick n type InGaN crack prevention layer 13 is formed. Then, carry out temperature up of the growing temperature to 1075 ** again, and TMAl (trimethylaluminum) which is a group III material is used, On the n type InGaN crack prevention layer 13, a n type $aluminum_{0.1}Ga_{0.9}N$ layer (Si-impurity concentration $1x10^{18}/cm^3$) is grown up, The 0.95-micrometer-thick n type AlGaN clad layer 14 is formed, and the 0.1-micrometer-thick n type GaN guide layer 15 is further formed on the n type AlGaN clad layer 14.

[0045]Lower growing temperature at 730 ** and on the n type GaN guide layer 15 Then, a 4-nm-thick $In_{0.15}Ga_{0.85}N$ quantum well layer, A 6-nm-thick $In_{0.05}Ga_{0.95}N$ barrier layer is formed by turns, and the barrier layer of four layers and the quantum well layer of three layers grow up the active layer of the multiple quantum well structure laminated periodically, and form the n type InGaN active layer 16. After laminating a barrier layer, until it makes a quantum well layer laminate, or by the time the n type InGaN active layer 16 makes a barrier layer laminate after laminating a quantum well layer, it may be set, and it may interrupt the crystal growth for 1 second - 180 seconds. By this operation, the surface smoothness of each class which the n type InGaN active layer 16 has improves, and luminescence half breadth decreases.

[0046]Next, to 1050 **, carry out temperature up of the growing temperature again, and on the n type InGaN active layer 16, A p type $aluminum_{0.2}Ga_{0.8}N$ layer is grown up, the 18-nm-thick p type AlGaN barrier layer 17 is formed, and the p type GaN guide layer 18 of 0.1 micrometer of thickness is further formed on the p type AlGaN barrier layer 17. In the p type AlGaN barrier layer 17 and the p type GaN guide layer 18, Mg is added as a p type impurity element by the concentration of $5x10^{19}/cm^3$ - $2x10^{20}/cm^3$. Then, on the p type GaN guide layer 18, a p type $aluminum_{0.1}Ga_{0.9}N$ layer is grown up, the 0.5-micrometer-thick p type AlGaN clad layer 19 is formed, and the 0.1-micrometer-thick p type GaN contact layer 20 is further formed on the p type AlGaN clad layer 19. In the p type AlGaN clad layer 19 and the p type GaN contact layer 20, Mg is added as a p type impurity element by the concentration of $5x10^{19}/cm^3$ - $2x10^{20}/cm^3$. As mentioned above, in each raw material of the element which constitutes each class of nitrides semiconductor laser. Cp2Mg (bis(cyclopentadienyl) magnesium), SiH_4,

etc. are used for each raw material of the impurity element (dopant) which uses TMGa, TMAl, TMIn, and NH3 grade, and is added on each class.
[0047]Thus, each class formed on the n type GaN board 11 when the wafer of the formed nitrides semiconductor laser was observed, As mentioned above, corresponding to the stepping structure which has a slot on the n type GaN board 11, it has structure which the high field of defect density and the very low field of defect density repeat periodically, and it is thought that it is based on the selective growth of the transverse direction from the n type GaN re-growth phase 23 currently formed in step shape. The defect by penetration transition etc. meets the center portion and the land upper surface of a groove (slot) on the n type GaN board 11, The place which had occurred mostly, divided into the range about 0.1 micrometer wide in parallel with a groove, and evaluated defect density, The center portion of a groove is a very high field of the defect density more than defect density $10^{10}cm^2$, A field of less than about 1 micrometer each is a high defect density field more than defect density 10^8cm^2 from the center of the both sides of the center portion of a groove, and the land upper surface is a high-density defect region more than defect density 10^8cm^2 similarly. To this result, the defect had been in very few (below a 10^7cm^2 grade) quality crystallized states in other fields in a groove.
[0048]To the wafer of such nitrides semiconductor laser, further After formation of the p type GaN contact layer 20, Dry etching removes the p type AlGaN clad layer 19 and the p type GaN contact layer 20 so that only a crosswise center section may remain, and ridge structure is formed so that the end of a stripe shape waveguide may be arranged from the center of a groove (slot) at a 2-micrometer position. As a result, the distance L of the end of a stripe shape waveguide and the high defect density field near the center of a groove is set to 1 micrometer. Then, the p type AlGaN clad layer 19 and the p type GaN contact layer 20 are covered with the insulator layer 22 so that only the upper surface of the p type GaN contact layer 20 may be exposed. The p type electrode (Pd/Mo/Au) 22 is formed over the upper surface which the p type GaN contact layer 20 exposed, and the insulator layer 21 upper surface. The p type electrode 22 has flowed electrically with the upper surface of the p type GaN contact layer 20.
[0049]Then, by grinding or etching the rear-face side of the n type GaN board 11, some n type GaN boards 11 are removed, and the thickness of a wafer is thinly adjusted by about 100-150 micrometers. It is operation for making it easy for this operation to divide a wafer by a post process, and to make it into each semiconductor laser chip. When forming the mirror of a laser end especially at the time of division, it is desirable to adjust to about 80-120 micrometers thinly. According to a 1st embodiment of this invention, although the thickness of the wafer was adjusted to 100 micrometers using the grinding machine and the grinder, only a grinder may adjust. Since the rear face of the wafer is ground by the grinder, it is flat.
[0050]After polish of the rear face of the n type GaN board 11, a thin metal membrane is vapor-deposited at the rear face of the n type GaN board 11, and the n type electrode 10 which has a laminated structure of Hf/A1/Mo/Au is formed in it. As a method of forming such a thin metal membrane, controlling thickness, the vacuum deposition method is suitable and this method was used also in a 1st embodiment of this invention. However, other methods, such as the ion plating method and a sputtering technique, may be used for the method of forming the n type electrode 10. In order that the p type electrode 23 and the n type electrode 10 may form an ohmic electrode with a good flow, annealing treatment of them is carried out by the temperature of 500 ** after metal membrane formation, respectively.
[0051]Thus, the manufactured semiconductor device is divided by the following method. First, a scribe line is put in by a diamond point from the surface of a wafer, suitably, power is applied to a wafer and a wafer is divided into it along with a scribe line. A scribe line may be put in from the rear face of a wafer. The dicing method for performing ****** or cutting, using a wire saw or a sheet metal braid as other methods of dividing a wafer, An irradiation part is made to produce a crack with exposure heating of laser beams, such as excimer laser, and subsequent quenching, It irradiates with the laser beam of the laser scribing method which makes this a scribe line, and high energy density, and the laser ablation method for evaporating this portion and performing grooving processing, etc. can be applied, and also when it is any, a wafer can be divided appropriately.
[0052]In the nitrides semiconductor laser which is a 1st embodiment of this invention, in the two end faces of a semiconductor laser element, the reflection film which has the reflectance of about 10% is formed in one end face, the reflection film which has the reflectance of about 80% is formed in the end face of another side, and unsymmetrical coating is carried out.
[0053]Next, by the die-bonding method, a nitride semiconductor laser chip is mounted on heat sinks, such as a stem, and a nitride semiconductor racer device is obtained. The nitride semiconductor laser chip was firmly pasted up by the junk rise which joins the n type electrode 10 to a heat sink. Here, heat sinks are things, such as a stem, Si sub mount, and Cu submount, and the photo detector etc. may be formed in Si sub mount.
[0054]Thus, the following result was obtained when the various characteristics of the manufactured nitrides

semiconductor laser were investigated. The cavity length of nitrides semiconductor laser is 450 micrometers, and stripe width is 2 micrometers. When this nitrides semiconductor laser performed continuous oscillation in the room temperature of 25 ** by the threshold current of 32 mA used as the laser oscillation starting point, the oscillation wavelength at that time was 405**5 nm. In the range of 21 mW, self-oscillation was obtained for optical power from 2 mW. When optical power was made to increase and the kink which shows the level which becomes the instability of laser oscillation horizontal transverse mode was investigated, the kink generation light output was set to not less than 70 mW, and this nitrides semiconductor laser has checked that optical power was a self-oscillating motion in the range of 2 to 21 mW.
[0055]Next, in the nitrides semiconductor laser which is a 1st embodiment of this invention, the position which forms the stripe shape waveguide which has ridge structure is changed, and the result of having checked the optical power range which produces self-oscillation is shown in Table 1. In the n type GaN board 11 which is a wafer of nitrides semiconductor laser, When the position which forms the above-mentioned stripe shape waveguide is changed, the distance L from the end of a stripe shape waveguide to the center of a high defect density field in 5 micrometers. It is the same as the case (L=infinity) where the groove (slot) structure which forms a level difference on the n type GaN board 11 is not established, and as compared with the nitrides semiconductor laser of a 1st embodiment, optical power becomes narrow with the range which is 3-6 mW, a kink generating output is also set to not less than 30 mW, and self-oscillation falls.
[0056]The effect in which L provided the groove (slot) structure which a kink generating output is set to not less than 50 mW by self-oscillation serving as a range whose optical power is 2-15 mW in 4 micrometers, and forms a level difference on the n type GaN board 11 is acquired. The effect in which L provided the groove (slot) structure which self-oscillation serves as a range whose optical power is 1-26 mW in 0.5 micrometer, and a kink generating output is set to not less than 70 mW, and forms a level difference on the n type GaN board 11 shows up notably.
[0057]At L= 0.3 micrometer smaller than 0.5 micrometer, continuous oscillation is no longer seen for L. This is considered to depend a stripe shape waveguide on the fall of a profit, since many careers poured into the stripe shape waveguide since a high defect density field will be in a wrap state selectively arrive at a high defect density field by diffusion and are consumed by unradiated recombination.
[0058]That existence of a defect influences the self-oscillation feature of nitrides semiconductor laser from this, Since the distance to which a career reaches a defect by diffusion is about 0.5 micrometer and the mean distance between defects is considered to be 1 micrometer or less of order, The defect of the defect density of the high defect density field where the recombination of a career is promoted should just be more than one piece (1-/micrometer^2=10^8/cm^2) 1-micrometer square.
[0059]In order to expand the range of the optical power which self-oscillation produces by clear distinguishing between the recombination of the career in this high defect density field and the field of a stripe shape waveguide, The defect density in the field of a stripe shape waveguide needs to be lower than the defect density of a high defect density field single or more figures. In the manufacturing process of the nitrides semiconductor laser of a 1st embodiment, if thickness of the n type re-growth phase 23 formed in the groove upper surface on the n type GaN board 11 is thickened, the difference of the defect density of a high defect density field and the defect density of the stripe shape waveguide which is a low defect density field will actually become small. Thus, the place which thickened thickness of the n type re-growth phase 23 and where the defect density of the field of a stripe shape waveguide produced the element which are 3x10^7 / cm^2 grade, The range of the optical power in which self-oscillation is possible is 3-7 mW, a kink generation light output is not less than 20 mW, and it has checked that there were not a case (L=infinity) where groove (slot) structure is not established on the n type GaN board 11, and a difference.
[0060]
[Table 1]

	L	自励発振範囲	キンク発生光出力	
本発明（実施の形態１）	１．０μｍ	２～２１ｍW	７０ｍW以上	
比較例	∞	３～６ｍW	２５ｍW以上	
比較例	５．０μｍ	３～６ｍW	３０ｍW以上	
本発明	４．０μｍ	２～１５ｍW	５０ｍW以上	
本発明	０．５μｍ	１～２６ｍW	７０ｍW以上	
比較例	０．３μｍ	×	×	
比較例	１．０μｍ	３～７ｍW	２０ｍW以上	＊ストライプ領域欠陥密度 ３×１０^{7}ｃｍ$^{-2}$

As a result, the nitrides semiconductor laser which is a 1st embodiment of this invention, When the defect density of the high defect density field used as a saturable absorption field is 10 or more times of the defect density in the low defect density field in which a stripe shape waveguide is formed and the defect density of a high defect density field carries out 10^8 / more than cm^2, The effect of expanding the range of the optical power in which self-oscillation is possible was acquired.Thus, the nitrides semiconductor laser of this invention will become very useful on system application, if operation of optical power is attained by low noise to the high-output range, for example, it uses for the light source for systems of an optical disc.

[0061]As shown in Table 1, corresponding to the range of the optical power in which self-oscillation is possible, a kink did not generate the nitrides semiconductor laser of this invention to high power. By this separating only the predetermined distance L mentioned above from the end of the stripe shape waveguide, and arranging the high defect density field used as a saturable absorption field, light distribution -- foundations -- the efficiency of an oscillation to the higher mode which has spread rather than next the mode -- foundations -- it is because it falls greatly relatively and the appearance of higher mode is controlled rather than the efficiency of an oscillation to next the mode. The noise (instability of operation) resulting from the instability of the horizontal transverse mode about which we are anxious especially at the time of high output operation is controlled, and the nitrides semiconductor laser with stable horizontal transverse mode at the time of such high output operation is dramatically useful, when it uses for the light source for optical disk systems.

[0062]Next, the nitrides semiconductor laser of a 2nd embodiment of this invention is explained. According to a 2nd embodiment, the quantum well layer of the n type InGaN active layer 16 of the nitrides semiconductor laser of a 1st embodiment was formed by GaNP, GaNAs, InGaNP, InGaNAs, etc. whose oscillation wavelength is 360-550 nm. Other composition is the same as that of the nitrides semiconductor laser of a 1st embodiment shown in drawing 1. Stabilization of horizontal transverse mode and expansion of the range of the optical power in which self-oscillation is possible were obtained like [nitrides semiconductor laser / of a 2nd embodiment] the nitrides semiconductor laser of a 1st embodiment.

[0063]Although physical relationship with the high defect density field on one near upper surface of a groove was explained to the stripe shape waveguide which has ridge structure in the nitrides semiconductor laser of a 1st embodiment, and the nitrides semiconductor laser of a 2nd embodiment, By arranging the high defect density field on the upper surface of a land which is an another side side at the same distance mentioned above from the stripe shape waveguide, it becomes a paired-right-and-left elephant focusing on a stripe shape waveguide, and the nitrides semiconductor laser of more desirable composition is obtained.

[0064]Although the groove (slot) which forms a level difference on the n type GaN board 11 was provided by this invention about the method of forming the high field of defect density, and the low field of defect density and the method of forming the n type GaN re-growth phase 23 on it was used, The method of re-growing up on the substrate of n type GaN board 11 grade may be used so that it is not necessary to restrict to this method, it may replace with a groove (slot) and growth promotion films, such as growth suppression films, such as SiO_2 and W, or AlN, may be arranged on a stripe. In a substrate material, it does not need to be limited to GaN, and the substrate material used as other substrates for nitride semiconductors, such as sapphire, SiC, and silicon, may be used.

[0065]Next, the noise characteristic over the returned light at the time of using the nitrides semiconductor laser of this invention for the light source for systems of an optical disc was investigated. Drawing 3 is a key map showing the optical information storage playback equipment which used the nitrides semiconductor laser of this invention. Optical information storage playback equipment comprises the lens 127 for condensing the nitrides semiconductor laser 122, the collimating lens 123, the branching element 124, the object lens 125, and catoptric light which were installed on the pedestal 121 and the pedestal 121, and photodetector 128 grade.

[0066]The light information record board (optical disc) 126 is set to the condensing point position of the object lens 125 by optical information storage playback equipment, and the light emitted from the nitrides semiconductor laser 122 at the time of playback, It is condensed by the information storage side of the light information record board 126 with the collimating lens 123 and the object lens 125. Information is written in the information storage side of the light information record board 126 by unevenness, magnetic abnormal conditions, refractive index modulation, or other means. It is reflected after becoming irregular there, and the laser beam condensed by the information storage side of the light information record board 126 is led to the photodetector 128 side by the branching element 124 through the object lens 125, and enters into the photodetector 128. The signal detected optically is changed into an electrical signal by the photodetector 128, and reading of recorded information is performed.

[0067]At the time of record, the light emitted from the nitrides semiconductor laser 122 with the collimating lens 123 and the object lens 125. By similarly, being condensed by the information storage side of the light

information record board 126, modulating the laser beam itself according to information, and modulating a refractive index or a magnetic field of an information storage side of the light information record board 126, etc. by this, The information storage side of the light information record board 126 is selectively heated by the influence of the laser beam which information was written in or was condensed, the magnetic field of the information storage side of the light information record board 126, etc. are modulated by giving a magnetic field to an information storage side simultaneously with this, and information is written in.
[0068]The noise of the optical information storage playback equipment using the nitrides semiconductor laser of this invention was measured by the following methods. It was made to oscillate continuously, and the laser beam vibrated delicately the information storage side of the light information record board 126, and evaluated relative noise field intensity (RIN:Relative IntensityNoise). It is known that an output will become unstable by interference with returned light (light which returns from the information storage side of the light information record board 126 to laser), and the laser which is carrying out continuous oscillation should just carry out self-oscillation a specific cycle, in order to have the low noise characteristic. First, when noise in case returned light is 0.1% - 10% was investigated in the case of 5 mW for optical power, it turned out that it is below RIN=-130 [dB/Hz]. Next, in order to investigate the noise characteristic over returned light in case optical power is high power, when optical power was about 15 mW, it is below RIN=-135 [dB/Hz] similarly and the low noise characteristic was maintained. As a result, the nitrides semiconductor laser of this invention has the stable self-oscillation feature, and has checked that it was suitable as a light source for optical disk systems.
[0069]In the case where optical power is 15 mW when the semiconductor laser of the column of the comparative example of Table 1 is chosen, it replaces with the light source of the above-mentioned optical information storage playback equipment and it carries, in order to compare with the nitrides semiconductor laser of this invention, By becoming maximum RIN=-110 [dB/Hz] grade, by such optical power, there was much noise and it has become clear that it is not suitable that it was used for an optical disk system etc.
[0070]It investigated also about the operation in high power which corresponds to write-in operation. When returned light was 0.1%, the nitrides semiconductor laser of this invention showed the operation where optical power was stabilized to not less than 40 mW, and relative noise field intensity was also below maximum RIN=-130 [dB/Hz], but. The semiconductor laser of the column of the comparative example of Table 1 was chosen, when it replaced with the light source of the above-mentioned optical information storage playback equipment and having been carried, [near the kink generation light output], relative noise field intensity became more than maximum RIN=-100 [dB/Hz], and very unstable operation was shown.
[0071]Therefore, in the nitrides semiconductor laser of this invention, while being able to build the system of low noise, little optical information storage playback equipment with faulty reading/writing operation is realizable.
[0072]
[Effect of the Invention]On the substrate, two or more semiconductor layers are laminated, and the semiconductor emission device of this invention is formed by the stripe shape waveguide, and in a substrate face. By forming the convex domain of the couple and forming one convex domain near the concave region so that a concave region may be formed in the field which counters a stripe shape waveguide, The carrier life of active layers other than a current injection region is shortened, and a self-oscillation feature with stable horizontal transverse mode is obtained also in the time of high output operation.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention]This invention is used for the information storage of an optical disc, playback, etc., and it relates to a semiconductor emission device which has a self-oscillation feature for low-noise-izing, a manufacturing method for the same, and optical information storage playback equipment while horizontal transverse mode is stable.

[Translation done.]

PRIOR ART

[Description of the Prior Art]With the increase in the storage capacity in an optical disc, as a light source for optical discs, the diameter of condensing is made small and the light source with a wavelength of around 400 nm which can record information in high density further is needed. Use of the material of a cheap plastic system is considered by the optical disk system to a lens, a disk, etc. for cost reduction. However, since an absorption-of-light end is the wavelength of about 390 nm at the maximum, the material of such a plastic system needs to perform further short wavelength formation as a light source for optical discs. For this reason, it is not easy for it to be necessary to examine the material as a light source, and to deal with fertilization. The semiconductor laser is conventionally used for the light source of such an optical disk system.
There is a gallium nitride compound semiconductor as a typical material of the semiconductor laser which has the wavelength of around 400 nm.

[0003]When nitrides semiconductor laser is used for an optical disk system etc., in order that the returned light noise from reflective spots, such as an optical disc, may be decreased, a structure provided with the self-oscillation feature is used.
[0004]Such nitrides semiconductor laser is indicated by JP,10-294532,A.
Drawing 4 is a sectional view showing a typical structure of the nitrides semiconductor laser.
By using for this gazette as a field (it is hereafter considered as a saturable absorption field) which has the saturable absorption characteristic that the amount of absorption of light is saturated in the island like areas of In which is a nonluminescent field, in the adjoining field of the active layer containing InGaN, A self-oscillation function is obtained and the semiconductor laser which returned light noise reduced is indicated.
[0005]As shown in drawing 4, as for this semiconductor laser, n type GaN buffer layer 71 and the n type GaN contact layer 72 are formed on the sapphire substrate 70.
On the predetermined field of the n type GaN contact layer 72, The n type AlGaN clad layer 73, the n type InGaN/GaN multiplex quantum well adjacent layer 74 which has island like areas of In, the InGaN/GaN multiplex quantum well active layer 75, the p type GaN adjacent layer 76, and the p type AlGaN clad layer 77 are laminated in order.
The stripe shape waveguide area 78a which constitutes a laser cavity is established in the center section on the p type AlGaN clad layer 77.
The n type GaN energization barrier layer 79 into which current is not made to pour in addition to a waveguide is formed in the outside of the stripe shape waveguide area 78a.
On the portion of the stripe shape waveguide area 78a, and the n type GaN energization barrier layer 79, the p type GaN contact layer 78 is formed. And the p lateral electrode 80 is formed on the p type GaN contact layer 78.
The n lateral electrode 81 is formed in portions other than the predetermined field of the above-mentioned on the n type GaN contact layer 72.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]As for the semiconductor emission device of this invention, on the substrate, two or more semiconductor layers are laminated and the stripe shape waveguide is provided.
In a substrate face, so that a concave region may be formed in the field which counters a stripe shape waveguide, By forming the convex domain of the couple and forming one convex domain near the concave region, the carrier life of active layers other than a current injection region is shortened, and a self-oscillation feature with stable horizontal transverse mode is obtained also in the time of high output operation.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]The nitrides semiconductor laser indicated by JP,10-294532,A, In the adjoining field of an active layer, since the island like areas 82 of In which is a nonluminescent field are used as a saturable absorption field, There is a possibility that a process control for forming an element to obtain a good self-oscillation feature easily as a result may become difficult carrying out a process control so that the island like areas 82 of In which produces optical absorption may hold a good absorption feature.
[0007]Without forming such island like areas 82 of In so that the saturable absorption characteristic may be given positively, By using the field of the active layer currently formed in the lower part of the field (energization barrier layer) where the current of the outside of a stripe shape waveguide is not poured in as a saturable absorption field, the art of the low noise semiconductor laser whose self-oscillating motion becomes possible is known. In this case, in order to make the self-oscillation of a low noise semiconductor laser maintain effectively, it is necessary to the carrier life of the active layer of a current injection region to shorten the carrier life of active layers other than a current injection region. However, it is not easy to be hard to diffuse the career generated by optical absorption in the saturable absorption field, and to shorten the life of the career on appearance in a nitride semiconductor, since the diffusion coefficient of a career is small, either.
[0008]In the conventional semiconductor laser, it is difficult to fully stabilize horizontal transverse mode at the time of high output operation, and there is a possibility that the noise which is change of optical power may be made.
[0009]This invention solves such a technical problem. The purpose shortens the carrier life of active layers other than a current injection region, and there is in providing a semiconductor emission device with which the self-oscillation feature where horizontal transverse mode was stabilized also in the time of high output operation is obtained, a manufacturing method for the same, and optical information storage playback equipment.

[0010]

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem]A semiconductor emission device of this invention is a semiconductor emission device with which two or more nitride semiconductor layers were laminated, and a stripe shape waveguide was formed on a substrate, and in this substrate face. A convex domain of a couple is formed and one convex domain is formed near [concave region] this so that a concave region may be formed in a field which counters this stripe shape waveguide.
[0011]Said concave region is formed between convex domains of said couple, and said stripe shape waveguide counters between this one convex domain and a center section of this concave region, and is arranged.
[0012]A semiconductor emission device of this invention is a semiconductor emission device with which two or more nitride semiconductor layers were laminated, and a stripe shape waveguide was formed on a substrate, and in this substrate face. A high field of defect density is formed near the field of the low defect density so that a field which counters this stripe shape waveguide may turn into a low field of defect density.
[0013]Said defect density is 10 or more times of defect density of a field which counters said stripe shape waveguide.
[0014]Said defect density is 10^8 / more than cm^2.
[0015]An interval of a high field of said defect density and said stripe shape waveguide is 0.5 micrometer - 4 micrometers.
[0016]A high field of said defect density has a saturable absorption field provided with the characteristic that the amount of absorption of light is saturated.
[0017]Stripe width of said stripe shape waveguide is 0.5 micrometer - 8 micrometers.
[0018]It has a self-oscillation feature by said stripe shape waveguide and said saturable absorption field.
[0019]A process at which a manufacturing method of a semiconductor emission device of this invention forms a convex domain and a concave region which adjoin mutually on a nitride semiconductor substrate of the 1st conductivity type, A process of forming a nitride semiconductor layer of the 1st conductivity type with the 1st growing temperature on a nitride semiconductor substrate of this 1st conductivity type, On a nitride semiconductor layer of this 1st conductivity type, with this 1st growing temperature and the 2nd different growing temperature, a nitride semiconductor crack prevention layer of the 1st conductivity type, A process of forming a nitride semiconductor cladding layer of the 1st conductivity type, and a nitride semiconductor guide layer of the 1st conductivity type in order with this 1st growing temperature, A process of forming a nitride semiconductor active layer of the 1st conductivity type with this 2nd growing temperature and the 3rd different growing temperature on a nitride semiconductor guide layer of this 1st conductivity type, On a nitride semiconductor active layer of this 1st conductivity type, with this 1st growing temperature, a nitride semiconductor barrier layer of the 2nd conductivity type, A process of forming a nitride semiconductor guide layer of the 2nd conductivity type, a nitride semiconductor cladding layer of the 2nd conductivity type, and a nitride semiconductor contact layer of the 2nd conductivity type in order, and a process of forming ridge structure by dry etching processing are included.
[0020]As for optical information storage playback equipment of this invention, the semiconductor emission device according to any one of claims 1 to 9 is used as a light source.
[0021]
[Embodiment of the Invention]The self-oscillation of a semiconductor laser is produced by the interaction of the career in the active layer (gain region) which the population inversion has produced with the career poured into the semiconductor laser, and the saturable absorption field which is fields provided with the saturable absorption characteristic, and a photon. . [whether the band gap substantial to the 1st of the characteristic required of a saturable absorption field is the same as that of the band gap of an active layer (gain region), and] Or it is slightly narrow, and the 2nd characteristic required of a saturable absorption field is that the life of the career of a saturable absorption field is shorter than the life of the career of an active layer, that the absorption of light is

saturated easily, etc. in order to make self-oscillation cause effectively.
[0022]In nitrides semiconductor laser, especially the life characteristic of the career in the saturable absorption field which is the 2nd characteristic required of a saturable absorption field is important. In order to know several ns and a short thing at the minimum and for the life of the career of a nitride system semiconductor to distinguish [clear] between the life of the career of an active layer and a saturable absorption field, It is possible to add impurity elements (for example, Mg etc.) at high concentration to a saturable absorption layer (doping), to promote diffusion of the career from the optical absorption field in a saturable absorption field to the outside of an optical absorption field, to make a career recombine efficiently, and to shorten the carrier life on appearance, etc.
[0023]In the conventional nitrides semiconductor laser, the current injection region (oscillation region corresponding to a stripe shape waveguide) of an active layer However, a gain region, When making it into the saturable absorption field which has the saturable absorption characteristic except the current injection region of an active layer, it is not easy clear to distinguish between the amount of addition (dope) of an impurity element in the field of both a gain region and a saturable absorption field. In order to shorten seemingly the life of the career generated by the saturable absorption field by optical absorption, the material property of the saturable absorption field which has a big diffusion coefficient which the generated career diffuses outside an optical absorption field to the order for several ns is required, but. In the saturable absorption field formed of InGaN etc., generally, since the diffusion coefficient is small, a career is made to recombine and the effect which shortens the life of a career is hard to be acquired by fully diffusing the career generated by the saturable absorption field.
[0024]By using for a GaN board the process of forming a level difference, about this point, in this invention, as a result of repeating examination, To the field in which the gain region and saturable absorption field of a semiconductor laser are formed. So that the high field of defect density and the low field of defect density may be formed, the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a gain region may be periodically arranged to the low field of defect density and the current injection region which is a gain region may be approached, By arranging the saturable absorption field which has the saturable absorption characteristic to the high field of defect density, the recombination of the prompt career by unradiated transition becomes possible. As a result, while the life of the effectual career in the saturable absorption field which is a high field of the defect density of the outside of the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a gain region in the formation area of a semiconductor laser becomes short, Self-oscillation becomes is easy to maintain in a gain region, and the nitrides semiconductor laser in which self-oscillation is possible to high power is obtained.
[0025]Near the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a low gain region of defect density, in this way, The absorption of light in the high saturable absorption field of this defect density can fully be maintained at the time of operation of a semiconductor laser by arranging the field which has the saturable absorption characteristic that defect density is high and the life of a career is short compared with a current injection region (oscillation region corresponding to a stripe shape waveguide). As a result, in nitride system semiconductor laser, By making into a predetermined value the difference of the defect density of the current injection region (oscillation region corresponding to a stripe shape waveguide) and the high saturable absorption field of defect density which are low gain regions of defect density, At the time of operation of nitride system semiconductor laser, the difference of the profit in the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a low gain region of defect density, and the absorption in the high saturable absorption field of defect density can be clearly attached now, Horizontal transverse mode comes to be stabilized to high power.
[0026]This invention is based on such knowledge.
[0027]In the nitrides semiconductor laser which attached the slot which forms a level difference in the surface of a GaN board, the land which is a convex domain of a level difference, and the groove which is the concave regions of a level difference are periodically formed by turns on the surface of a GaN board. When predetermined conditions prescribed these widths of land, the width of a groove, the depth of a groove, and the thickness of the re-growth phase formed on the GaN board which has stepping structure, according to the stepping structure, it has checked that the high field of defect density and the low field of defect density existed in a re-growth phase. By etch pit observation and TEM (transmission electron microscope) observation of this re-growth phase, it has also checked that the high field of defect density was formed in the center portion on the upper surface of a groove, and the land upper surface. In [as for this, the growth from the side of a land is chosen from the growth from the upper surface of a groove as dominance at the time of the re-growth from the GaN board for which the level difference was formed as for the re-growth phase, and] a groove top as a result, Defects, such as

penetration dislocation, converge on the center portion on a groove, and are considered that defects, such as penetration dislocation, decrease in fields other than the center portion on a groove.
[0028]That the upper surface of a land or the center portion of a groove has not been thoroughly buried with a re-growth phase, and the slot on the level difference remains when the thickness of a re-growth phase is thin for a certain reason. The conditions in which a level difference is formed were changed, the field with various defect density was formed, and the stability of change of the self-oscillation feature of nitrides semiconductor laser and the horizontal transverse mode at the time of high output operation was investigated.
[0029]If the low field of defect density has good crystallinity and the stripe shape waveguide (current injection region which is a gain region) of ridge structure is formed in this field, the poured-in career, Radiation recombination was carried out effectively and nitrides semiconductor laser with high slope efficiency which is a rate of the increase in light intensity over the rate of the increase in an inrush current was obtained. In the high field of defect density, the rate of the relaxation to the low energy level resulting from the rate and defect of unradiated recombination increases, and the recombination of the career generated by the optical absorption in active layers other than the current injection region which is a gain region is promoted. As a result, the life of the career of the saturable absorption field which is a high field of defect density becomes short, and is effective for stabilization of horizontal transverse mode continuation of the self-oscillation in nitrides semiconductor laser, and high-output.
[0030]As mentioned above, it is better for the one where the difference of the defect density of the high portion of defect density and the low portion of defect density is larger to change steeply [the difference of defect density] well the optimal on the boundary as a substrate required of the nitrides semiconductor laser which has a self-oscillation feature.
[0031]When this invention examines the conditions for which a level difference is formed in a GaN board about such a point, if the depth of 4 micrometers - 30 micrometers, and a groove is 1 micrometer - 10 micrometers, groove width 0.1 micrometer - 5 micrometers, and a re-growth phase, The check of being effective in the nitrides semiconductor laser which has a self-oscillation feature was obtained. Here, in the depth of a groove, if thickness of the re-growth phase on A and a groove is set to B, and it is 20A>=B>=2A, the above-mentioned effect will be acquired. As a result of observing the surface of the GaN board which has such stepping structure, the high field of defect density and the low field of defect density had produced on the center section of the upper surface of the groove on a GaN board, and the upper surface of the land, respectively. What is necessary is just to set a land width as 3 micrometers - about 20 micrometers, in arranging a land and a groove periodically on a GaN board. What is necessary is just to form a groove on a GaN substrate face at this time, so that a stripe shape waveguide may be countered. By being symmetrically arranged to the stripe shape waveguide (current injection region which is a gain region) of ridge structure, the light distribution in horizontal transverse mode is applicable, and the high field of defect density has it. [preferred] As a result, groove width should just be 10 micrometers - 20 micrometers. The defect density of the high field of defect density is 10 or more times of the defect density of the low field of defect density, and the defect density of the high field of defect density should just be more than $10^8 cm^{-2}$.
[0032]Next, arrangement of the current injection region (oscillation region corresponding to a stripe shape waveguide) which is a gain region, Since the amount of absorption of light in the saturable absorption field for control of a self-oscillation feature and stabilization of horizontal transverse mode needs to be controlled, The design of the thickness of an active layer, the distance from a saturable absorption field to the end of the stripe shape waveguide of ridge structure, stripe width (width of an average of the upper part of ridge structure and the lower part), etc. is needed. As for stripe width, the good result was obtained in 0.5 micrometer - 8 micrometers, and, as for the distance to the end of the stripe shape waveguide of ridge structure, the good result was obtained from the high saturable absorption field of defect density in 0.5 micrometer - 4 micrometers. If stripe width is set to less than 0.5 micrometer, the light distribution of the horizontal transverse mode in a gain region will become small, and profit sufficient as a semiconductor laser will not be acquired. If stripe width is expanded, can set the light distribution in active layers other than the gain region equivalent to a saturable absorption field as the suitable range, and the effect which shortens the life of a career will be easy to be acquired, but if stripe width exceeds 8 micrometers, The threshold current used as the laser oscillation starting point becomes high, and a long life is not acquired as a semiconductor laser.
[0033]In order that the high field of defect density may shorten the life of the career generated in active layers other than the current injection region which is a gain region by relaxation to the low energy level resulting from unradiated recombination and a defect, It is necessary to arrange in the distance which can diffuse the career which has been arranged at the skirt of the light distribution of the horizontal transverse mode in a laser oscillation state, or was generated in time shorter than the life (severalns-) of the career of the active layer of

the current injection region which is a gain region. When the distance from the high saturable absorption field of defect density to the end of the stripe shape waveguide of ridge structure is less than 0.5 micrometer, The inside of the current injection region (oscillation region) of a stripe shape-like waveguide is covered with the high field of defect density, the threshold current used as the laser oscillation starting point goes up remarkably, and there is a possibility that continuous oscillation may not be carried out in a room temperature.
[0034]If the distance from the high saturable absorption field of defect density to the end of the stripe shape waveguide of ridge structure exceeds 4 micrometers, the self-oscillation feature as a semiconductor laser will not be obtained, and, similarly the stability of the light distribution of the horizontal transverse mode at the time of high power will not be obtained. In order that from the skirt of the light distribution of the horizontal transverse mode in a laser oscillation state to the saturable absorption field which is a high field of defect density may leave this too much, It is because the career generated by optical absorption cannot be spread to the high saturable absorption field of defect density in a short time and effects, such as unradiated recombination, are not acquired.
[0035]As for an active layer, it is preferred to have multiple quantum well structure, and if the thickness of an active layer is 5 nm - 200 nm as the sum of a quantum well layer and a barrier layer, a self-oscillation feature will be obtained in nitrides semiconductor laser. case the thickness of an active layer is thick -- the ratio of vertical optical confinement factor gamma and thickness d of an active layer -- if gamma/d is fixed, in fixed optical power, a light absorption amount will become large rather than the case where the thickness of an active layer is thin. Since the carrier density in the active layer of the current injection region which is a gain region also decreases in this case, the life of a career also becomes long and self-oscillation happens easily in nitrides semiconductor laser. However, if the thickness of an active layer exceeds 200 nm as a result of the threshold current used as the laser oscillation starting point becoming high and pouring electric power's becoming large since a profit is hard to be acquired in the current injection region which is a gain region when the thickness of the active layer became thick too much, even if it carries out continuous oscillation, it will quench for a short time.
[0036]Thus, in this invention, the nitrides semiconductor laser which has the structure of reducing the noise induced by returned light was obtained by attaching the slot which forms a level difference in the surface of a GaN board with the self-oscillation where horizontal transverse mode was stabilized in broad optical power.
[0037]Drawing 1 is a cross-sectional view of the nitrides semiconductor laser which is a semiconductor emission device of a 1st embodiment of this invention.
[0038]On the n type GaN board 11 with which the slot which forms a level difference in the surface is attached, The n type GaN re-growth phase 23, the n type GaN layer 12, the n type InGaN crack prevention layer 13, the n type AlGaN clad layer 14, the n type GaN guide layer 15, the n type InGaN active layer 16, the p type AlGaN barrier layer 17, and the p type GaN guide layer 18 are laminated in order. The p type AlGaN clad layer 19 is laminated by the p type GaN guide layer 18, the p type AlGaN clad layer 19 has ridge structure which the center section of the cross direction which intersects perpendicularly with a stripe direction projected, and the p type GaN contact layer 20 is laminated on the lobe. In the side of the p type AlGaN clad layer 19 and the p type GaN contact layer 20, on the p type AlGaN clad layer 19. Except for the upper surface of the p type GaN contact layer 20, the insulator layer 21 is formed and the p type electrode 22 is formed in the upper surface of the insulator layer 21 and the p type GaN contact layer 20. The n type electrode 10 is formed in the n type GaN board 11 side.
[0039]Thus, the nitrides semiconductor laser which is a 1st embodiment of this invention shown in drawing 1 has the stripe shape refractive-index waveguide which used ridge structure.
[0040]Drawing 2 is a mimetic diagram showing the physical relationship of the stripe shape waveguide which is a current injection region of the nitrides semiconductor laser shown in drawing 1, and the high defect density field which is saturable absorption fields. In drawing 2, the field A shows the low defect density field which has a stripe shape waveguide which is a current injection region where defect density is low, and the high defect density field whose field B is a saturable absorption field where defect density is high, and L shows the distance from the end of a stripe shape waveguide to the center of a high defect density field. In drawing 2, stripe width is 2 micrometers and L is 1 micrometer. As for the cavity length of nitrides semiconductor laser, the rear-face reflectance of a resonator of 450 micrometers and the front reflectance of a resonator is 85% 20%. The depth of a ridge is adjusted so that a horizontal optical confinement factor may be set to 0.88-0.97.
[0041]The manufacturing method of the nitrides semiconductor laser which is a 1st embodiment of this invention is explained below, referring to drawing 1. The epitaxial grown method shown below is a method of growing up a crystal film on a substrate, VPE (the gaseous phase -- epitaxial) -- law and CVD (chemicals gaseous phase deposition) -- law. MOVPE (the organic metal gaseous phase -- epitaxial) -- law and MOCVD (organometal

chemistry gaseous phase deposition) -- law. Halide-VPE (the halogenation study gaseous phase -- epitaxial) -- law, the MBE (molecular beam epitaxial) method, and MOMBE (an organometallic molecule line -- epitaxial) -- law and GSMBE (gaseous raw material molecular beam epitaxial) -- law and CBE (a chemicals beam -- epitaxial) -- law etc. are included.

[0042]First, the n type GaN board 11 is formed. On the GaN single crystal membrane of about 500-micrometer thickness, a pitch interval is 20 micrometers and the n type GaN board 11 provides a depth of 2.5 micrometers, and an about [width 15micrometer] slot (groove) in a pitch interval.

[0043]Next, each gallium nitride semiconductor layer which nitrides semiconductor laser constitutes is laminated with an epitaxial grown method on the n type GaN board 11. In this case, the n type GaN board 11 is first set in the furnace of a MOCVD (organometal chemistry gaseous phase deposition) device, Using NH_3 of V group material, and TMGa (trimethylgallium) of a group III material, a low-temperature GaN buffer layer is grown up with the growing temperature of 550 **, and a 25-nm-thick low-temperature GaN buffer layer is formed on the n type GaN board 11. On this low-temperature GaN buffer layer, temperature up is carried out to the growing temperature of 1075 **, SiH_4 is added to two kinds of above-mentioned raw materials, and the n type GaN re-growth phase 23 about 3.5 micrometers thick is newly laminated with an epitaxial grown method. The 0.5-micrometer-thick n type GaN layer 12 (Si-impurity concentration $1x10^{18}/cm^3$) is formed on the n type GaN re-growth phase 23.

[0044]Then, lowering growing temperature at 700 ** - about 800 **, and supplying TMIn (trimethylindium) which is a group III material. On the n type GaN layer 12, a n type $In_{0.07}Ga_{0.93}N$ layer is grown up, and the 50-nm-thick n type InGaN crack prevention layer 13 is formed. Then, carry out temperature up of the growing temperature to 1075 ** again, and TMAl (trimethylaluminum) which is a group III material is used, On the n type InGaN crack prevention layer 13, a n type $aluminum_{0.1}Ga_{0.9}N$ layer (Si-impurity concentration $1x10^{18}/cm^3$) is grown up, The 0.95-micrometer-thick n type AlGaN clad layer 14 is formed, and the 0.1-micrometer-thick n type GaN guide layer 15 is further formed on the n type AlGaN clad layer 14.

[0045]Lower growing temperature at 730 ** and on the n type GaN guide layer 15 Then, a 4-nm-thick $In_{0.15}Ga_{0.85}N$ quantum well layer, A 6-nm-thick $In_{0.05}Ga_{0.95}N$ barrier layer is formed by turns, and the barrier layer of four layers and the quantum well layer of three layers grow up the active layer of the multiple quantum well structure laminated periodically, and form the n type InGaN active layer 16. After laminating a barrier layer, until it makes a quantum well layer laminate, or by the time the n type InGaN active layer 16 makes a barrier layer laminate after laminating a quantum well layer, it may be set, and it may interrupt the crystal growth for 1 second - 180 seconds. By this operation, the surface smoothness of each class which the n type InGaN active layer 16 has improves, and luminescence half breadth decreases.

[0046]Next, to 1050 **, carry out temperature up of the growing temperature again, and on the n type InGaN active layer 16, A p type $aluminum_{0.2}Ga_{0.8}N$ layer is grown up, the 18-nm-thick p type AlGaN barrier layer 17 is formed, and the p type GaN guide layer 18 of 0.1 micrometer of thickness is further formed on the p type AlGaN barrier layer 17. In the p type AlGaN barrier layer 17 and the p type GaN guide layer 18, Mg is added as a p type impurity element by the concentration of $5x10^{19}/cm^3$ - $2x10^{20}/cm^3$. Then, on the p type GaN guide layer 18, a p type $aluminum_{0.1}Ga_{0.9}N$ layer is grown up, the 0.5-micrometer-thick p type AlGaN clad layer 19 is formed, and the 0.1-micrometer-thick p type GaN contact layer 20 is further formed on the p type AlGaN clad layer 19. In the p type AlGaN clad layer 19 and the p type GaN contact layer 20, Mg is added as a p type impurity element by the concentration of $5x10^{19}/cm^3$ - $2x10^{20}/cm^3$. As mentioned above, in each raw material of the element which constitutes each class of nitrides semiconductor laser. Cp2Mg (bis(cyclopentadienyl) magnesium), SiH_4, etc. are used for each raw material of the impurity element (dopant) which uses TMGa, TMAl, TMIn, and NH3 grade, and is added on each class.

[0047]Thus, each class formed on the n type GaN board 11 when the wafer of the formed nitrides semiconductor laser was observed, As mentioned above, corresponding to the stepping structure which has a slot on the n type GaN board 11, it has structure which the high field of defect density and the very low field of defect density repeat periodically, and it is thought that it is based on the selective growth of the transverse direction from the n type GaN re-growth phase 23 currently formed in step shape. The defect by penetration transition etc. meets the center portion and the land upper surface of a groove (slot) on the n type GaN board 11, The place which had occurred mostly, divided into the range about 0.1 micrometer wide in parallel with a groove, and evaluated defect density, The center portion of a groove is a very high field of the defect density more than defect density $10^{10}cm^2$, A field of less than about 1 micrometer each is a high defect density field more than defect density

$10^8 cm^2$ from the center of the both sides of the center portion of a groove, and the land upper surface is a high-density defect region more than defect density $10^8 cm^2$ similarly. To this result, the defect had been in very few (below a $10^7 cm^2$ grade) quality crystallized states in other fields in a groove.
[0048]To the wafer of such nitrides semiconductor laser, further After formation of the p type GaN contact layer 20, Dry etching removes the p type AlGaN clad layer 19 and the p type GaN contact layer 20 so that only a crosswise center section may remain, and ridge structure is formed so that the end of a stripe shape waveguide may be arranged from the center of a groove (slot) at a 2-micrometer position. As a result, the distance L of the end of a stripe shape waveguide and the high defect density field near the center of a groove is set to 1 micrometer. Then, the p type AlGaN clad layer 19 and the p type GaN contact layer 20 are covered with the insulator layer 22 so that only the upper surface of the p type GaN contact layer 20 may be exposed. The p type electrode (Pd/Mo/Au) 22 is formed over the upper surface which the p type GaN contact layer 20 exposed, and the insulator layer 21 upper surface. The p type electrode 22 has flowed electrically with the upper surface of the p type GaN contact layer 20.
[0049]Then, by grinding or etching the rear-face side of the n type GaN board 11, some n type GaN boards 11 are removed, and the thickness of a wafer is thinly adjusted by about 100-150 micrometers. It is operation for making it easy for this operation to divide a wafer by a post process, and to make it into each semiconductor laser chip. When forming the mirror of a laser end especially at the time of division, it is desirable to adjust to about 80-120 micrometers thinly. According to a 1st embodiment of this invention, although the thickness of the wafer was adjusted to 100 micrometers using the grinding machine and the grinder, only a grinder may adjust. Since the rear face of the wafer is ground by the grinder, it is flat.
[0050]After polish of the rear face of the n type GaN board 11, a thin metal membrane is vapor-deposited at the rear face of the n type GaN board 11, and the n type electrode 10 which has a laminated structure of Hf/A1/Mo/Au is formed in it. As a method of forming such a thin metal membrane, controlling thickness, the vacuum deposition method is suitable and this method was used also in a 1st embodiment of this invention. However, other methods, such as the ion plating method and a sputtering technique, may be used for the method of forming the n type electrode 10. In order that the p type electrode 23 and the n type electrode 10 may form an ohmic electrode with a good flow, annealing treatment of them is carried out by the temperature of 500 ** after metal membrane formation, respectively.
[0051]Thus, the manufactured semiconductor device is divided by the following method. First, a scribe line is put in by a diamond point from the surface of a wafer, suitably, power is applied to a wafer and a wafer is divided into it along with a scribe line. A scribe line may be put in from the rear face of a wafer. The dicing method for performing ****** or cutting, using a wire saw or a sheet metal braid as other methods of dividing a wafer, An irradiation part is made to produce a crack with exposure heating of laser beams, such as excimer laser, and subsequent quenching, It irradiates with the laser beam of the laser scribing method which makes this a scribe line, and high energy density, and the laser ablation method for evaporating this portion and performing grooving processing, etc. can be applied, and also when it is any, a wafer can be divided appropriately.
[0052]In the nitrides semiconductor laser which is a 1st embodiment of this invention, in the two end faces of a semiconductor laser element, the reflection film which has the reflectance of about 10% is formed in one end face, the reflection film which has the reflectance of about 80% is formed in the end face of another side, and unsymmetrical coating is carried out.
[0053]Next, by the die-bonding method, a nitride semiconductor laser chip is mounted on heat sinks, such as a stem, and a nitride semiconductor racer device is obtained. The nitride semiconductor laser chip was firmly pasted up by the junk rise which joins the n type electrode 10 to a heat sink. Here, heat sinks are things, such as a stem, Si sub mount, and Cu submount, and the photo detector etc. may be formed in Si sub mount.
[0054]Thus, the following result was obtained when the various characteristics of the manufactured nitrides semiconductor laser were investigated. The cavity length of nitrides semiconductor laser is 450 micrometers, and stripe width is 2 micrometers. When this nitrides semiconductor laser performed continuous oscillation in the room temperature of 25 ** by the threshold current of 32 mA used as the laser oscillation starting point, the oscillation wavelength at that time was 405**5 nm. In the range of 21 mW, self-oscillation was obtained for optical power from 2 mW. When optical power was made to increase and the kink which shows the level which becomes the instability of laser oscillation horizontal transverse mode was investigated, the kink generation light output was set to not less than 70 mW, and this nitrides semiconductor laser has checked that optical power was a self-oscillating motion in the range of 2 to 21 mW.
[0055]Next, in the nitrides semiconductor laser which is a 1st embodiment of this invention, the position which forms the stripe shape waveguide which has ridge structure is changed, and the result of having checked the optical power range which produces self-oscillation is shown in Table 1. In the n type GaN board 11 which is a

wafer of nitrides semiconductor laser, When the position which forms the above-mentioned stripe shape waveguide is changed, the distance L from the end of a stripe shape waveguide to the center of a high defect density field in 5 micrometers. It is the same as the case (L=infinity) where the groove (slot) structure which forms a level difference on the n type GaN board 11 is not established, and as compared with the nitrides semiconductor laser of a 1st embodiment, optical power becomes narrow with the range which is 3-6 mW, a kink generating output is also set to not less than 30 mW, and self-oscillation falls.
[0056]The effect in which L provided the groove (slot) structure which a kink generating output is set to not less than 50 mW by self-oscillation serving as a range whose optical power is 2-15 mW in 4 micrometers, and forms a level difference on the n type GaN board 11 is acquired. The effect in which L provided the groove (slot) structure which self-oscillation serves as a range whose optical power is 1-26 mW in 0.5 micrometer, and a kink generating output is set to not less than 70 mW, and forms a level difference on the n type GaN board 11 shows up notably.
[0057]At L= 0.3 micrometer smaller than 0.5 micrometer, continuous oscillation is no longer seen for L. This is considered to depend a stripe shape waveguide on the fall of a profit, since many careers poured into the stripe shape waveguide since a high defect density field will be in a wrap state selectively arrive at a high defect density field by diffusion and are consumed by unradiated recombination.
[0058]That existence of a defect influences the self-oscillation feature of nitrides semiconductor laser from this, Since the distance to which a career reaches a defect by diffusion is about 0.5 micrometer and the mean distance between defects is considered to be 1 micrometer or less of order, The defect of the defect density of the high defect density field where the recombination of a career is promoted should just be more than one piece (1-/micrometer^2=10^8/cm^2) 1-micrometer square.
[0059]In order to expand the range of the optical power which self-oscillation produces by clear distinguishing between the recombination of the career in this high defect density field and the field of a stripe shape waveguide, The defect density in the field of a stripe shape waveguide needs to be lower than the defect density of a high defect density field single or more figures. In the manufacturing process of the nitrides semiconductor laser of a 1st embodiment, if thickness of the n type re-growth phase 23 formed in the groove upper surface on the n type GaN board 11 is thickened, the difference of the defect density of a high defect density field and the defect density of the stripe shape waveguide which is a low defect density field will actually become small. Thus, the place which thickened thickness of the n type re-growth phase 23 and where the defect density of the field of a stripe shape waveguide produced the element which are 3x10^7 / cm^2 grade, The range of the optical power in which self-oscillation is possible is 3-7 mW, a kink generation light output is not less than 20 mW, and it has checked that there were not a case (L=infinity) where groove (slot) structure is not established on the n type GaN board 11, and a difference.
[0060]
[Table 1]

	L	自励発振範囲	キンク発生光出力	
本発明（実施の形態１）	１．０μm	２～２１mW	７０mW以上	
比較例	∞	３～６mW	２５mW以上	
比較例	５．０μm	３～６mW	３０mW以上	
本発明	４．０μm	２～１５mW	５０mW以上	
本発明	０．５μm	１～２６mW	７０mW以上	
比較例	０．３μm	×	×	
比較例	１．０μm	３～７mW	２０mW以上	＊ストライプ領域欠陥密度 $3\times10^{7}cm^{-2}$

As a result, the nitrides semiconductor laser which is a 1st embodiment of this invention, When the defect density of the high defect density field used as a saturable absorption field is 10 or more times of the defect density in the low defect density field in which a stripe shape waveguide is formed and the defect density of a high defect density field carries out 10^8 / more than cm^2, The effect of expanding the range of the optical power in which self-oscillation is possible was acquired.Thus, the nitrides semiconductor laser of this invention will become very useful on system application, if operation of optical power is attained by low noise to the high-output range, for example, it uses for the light source for systems of an optical disc.
[0061]As shown in Table 1, corresponding to the range of the optical power in which self-oscillation is possible, a kink did not generate the nitrides semiconductor laser of this invention to high power. By this separating only the predetermined distance L mentioned above from the end of the stripe shape waveguide, and arranging the high defect density field used as a saturable absorption field, light distribution -- foundations -- the efficiency of an

oscillation to the higher mode which has spread rather than next the mode -- foundations -- it is because it falls greatly relatively and the appearance of higher mode is controlled rather than the efficiency of an oscillation to next the mode. The noise (instability of operation) resulting from the instability of the horizontal transverse mode about which we are anxious especially at the time of high output operation is controlled, and the nitrides semiconductor laser with stable horizontal transverse mode at the time of such high output operation is dramatically useful, when it uses for the light source for optical disk systems.
[0062]Next, the nitrides semiconductor laser of a 2nd embodiment of this invention is explained. According to a 2nd embodiment, the quantum well layer of the n type InGaN active layer 16 of the nitrides semiconductor laser of a 1st embodiment was formed by GaNP, GaNAs, InGaNP, InGaNAs, etc. whose oscillation wavelength is 360-550 nm. Other composition is the same as that of the nitrides semiconductor laser of a 1st embodiment shown in drawing 1. Stabilization of horizontal transverse mode and expansion of the range of the optical power in which self-oscillation is possible were obtained like [nitrides semiconductor laser / of a 2nd embodiment] the nitrides semiconductor laser of a 1st embodiment.
[0063]Although physical relationship with the high defect density field on one near upper surface of a groove was explained to the stripe shape waveguide which has ridge structure in the nitrides semiconductor laser of a 1st embodiment, and the nitrides semiconductor laser of a 2nd embodiment, By arranging the high defect density field on the upper surface of a land which is an another side side at the same distance mentioned above from the stripe shape waveguide, it becomes a paired-right-and-left elephant focusing on a stripe shape waveguide, and the nitrides semiconductor laser of more desirable composition is obtained.
[0064]Although the groove (slot) which forms a level difference on the n type GaN board 11 was provided by this invention about the method of forming the high field of defect density, and the low field of defect density and the method of forming the n type GaN re-growth phase 23 on it was used, The method of re-growing up on the substrate of n type GaN board 11 grade may be used so that it is not necessary to restrict to this method, it may replace with a groove (slot) and growth promotion films, such as growth suppression films, such as SiO_2 and W, or AlN, may be arranged on a stripe. In a substrate material, it does not need to be limited to GaN, and the substrate material used as other substrates for nitride semiconductors, such as sapphire, SiC, and silicon, may be used.
[0065]Next, the noise characteristic over the returned light at the time of using the nitrides semiconductor laser of this invention for the light source for systems of an optical disc was investigated. Drawing 3 is a key map showing the optical information storage playback equipment which used the nitrides semiconductor laser of this invention. Optical information storage playback equipment comprises the lens 127 for condensing the nitrides semiconductor laser 122, the collimating lens 123, the branching element 124, the object lens 125, and catoptric light which were installed on the pedestal 121 and the pedestal 121, and photodetector 128 grade.
[0066]The light information record board (optical disc) 126 is set to the condensing point position of the object lens 125 by optical information storage playback equipment, and the light emitted from the nitrides semiconductor laser 122 at the time of playback, It is condensed by the information storage side of the light information record board 126 with the collimating lens 123 and the object lens 125. Information is written in the information storage side of the light information record board 126 by unevenness, magnetic abnormal conditions, refractive index modulation, or other means. It is reflected after becoming irregular there, and the laser beam condensed by the information storage side of the light information record board 126 is led to the photodetector 128 side by the branching element 124 through the object lens 125, and enters into the photodetector 128. The signal detected optically is changed into an electrical signal by the photodetector 128, and reading of recorded information is performed.
[0067]At the time of record, the light emitted from the nitrides semiconductor laser 122 with the collimating lens 123 and the object lens 125. By similarly, being condensed by the information storage side of the light information record board 126, modulating the laser beam itself according to information, and modulating a refractive index or a magnetic field of an information storage side of the light information record board 126, etc. by this, The information storage side of the light information record board 126 is selectively heated by the influence of the laser beam which information was written in or was condensed, the magnetic field of the information storage side of the light information record board 126, etc. are modulated by giving a magnetic field to an information storage side simultaneously with this, and information is written in.
[0068]The noise of the optical information storage playback equipment using the nitrides semiconductor laser of this invention was measured by the following methods. It was made to oscillate continuously, and the laser beam vibrated delicately the information storage side of the light information record board 126, and evaluated relative noise field intensity (RIN:Relative IntensityNoise). It is known that an output will become unstable by interference with returned light (light which returns from the information storage side of the light information record board

126 to laser), and the laser which is carrying out continuous oscillation should just carry out self-oscillation a specific cycle, in order to have the low noise characteristic. First, when noise in case returned light is 0.1% - 10% was investigated in the case of 5 mW for optical power, it turned out that it is below RIN=-130 [dB/Hz]. Next, in order to investigate the noise characteristic over returned light in case optical power is high power, when optical power was about 15 mW, it is below RIN=-135 [dB/Hz] similarly and the low noise characteristic was maintained. As a result, the nitrides semiconductor laser of this invention has the stable self-oscillation feature, and has checked that it was suitable as a light source for optical disk systems.

[0069]In the case where optical power is 15 mW when the semiconductor laser of the column of the comparative example of Table 1 is chosen, it replaces with the light source of the above-mentioned optical information storage playback equipment and it carries, in order to compare with the nitrides semiconductor laser of this invention, By becoming maximum RIN=-110 [dB/Hz] grade, by such optical power, there was much noise and it has become clear that it is not suitable that it was used for an optical disk system etc.

[0070]It investigated also about the operation in high power which corresponds to write-in operation. When returned light was 0.1%, the nitrides semiconductor laser of this invention showed the operation where optical power was stabilized to not less than 40 mW, and relative noise field intensity was also below maximum RIN=-130 [dB/Hz], but. The semiconductor laser of the column of the comparative example of Table 1 was chosen, when it replaced with the light source of the above-mentioned optical information storage playback equipment and having been carried, [near the kink generation light output], relative noise field intensity became more than maximum RIN=-100 [dB/Hz], and very unstable operation was shown.

[0071]Therefore, in the nitrides semiconductor laser of this invention, while being able to build the system of low noise, little optical information storage playback equipment with faulty reading/writing operation is realizable.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a cross-sectional view of the semiconductor emission device which is a 1st embodiment of this invention.
[Drawing 2]It is a mimetic diagram showing the physical relationship of the stripe shape waveguide of the semiconductor emission device of drawing 1, and a high defect density field.
[Drawing 3]It is a schematic diagram of the optical information storage playback equipment using the semiconductor emission device of this invention.
[Drawing 4]It is a cross-sectional view of the nitrides semiconductor laser which is the conventional semiconductor emission device.
[Description of Notations]
10 N electrode
11 N type GaN board
12 N type GaN layer
13 N type InGaN crack prevention layer
14 N type AlGaN clad layer
15 N type GaN guide layer
16 N type InGaN active layer
17 P type AlGaN barrier layer
18 P type GaN guide layer
19 P type AlGaN clad layer
20 P type GaN contact layer
21 Insulator layer
22 P electrode
23 N type GaN re-growth phase

[Translation done.]

* NOTICES *

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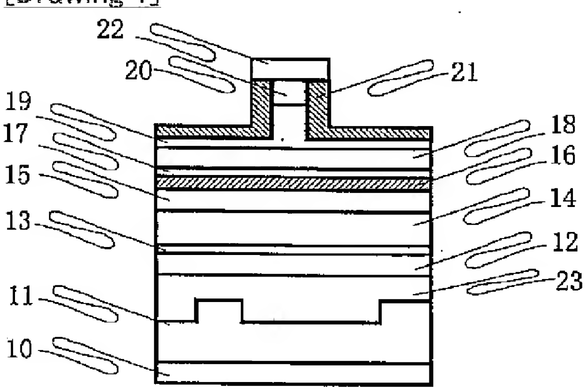
damages caused by the use of this translation.

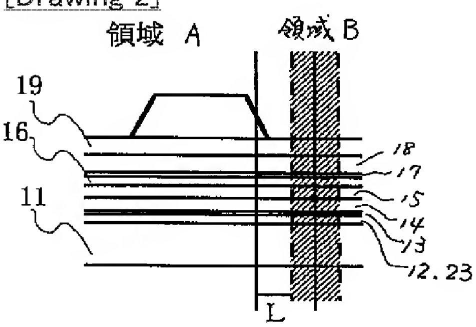
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

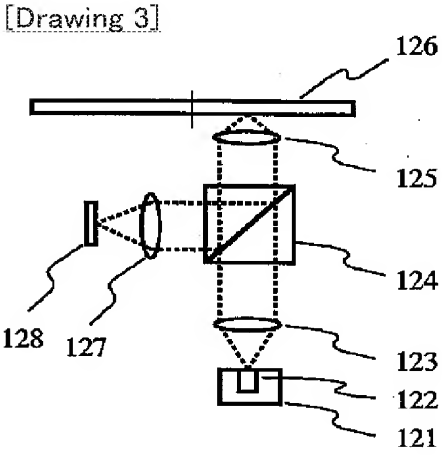
[Drawing 1]



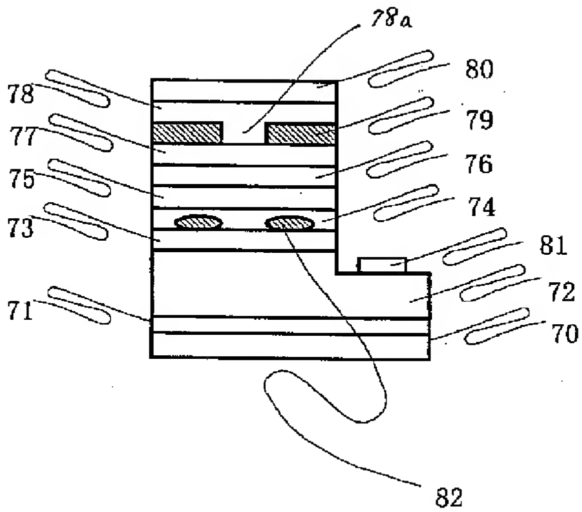
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]